

Address of the President, Lord Rayleigh, O.M., D.C.L., at the Anniversary Meeting on November 30, 1906

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REFERENCES.

- Bradford, 'Journ. Physiol.,' vol. 23, p. 415, 1898.
 Folin, 'Journ. Phys. Amer.,' vol. 13, 1905.
 Kaufmann, 'Zeitschrift f. Biol.,' vol. 41, 1901.
 Schöndorff, 'Pflüger's Archiv,' vol. 82, p. 60, 1900.
 Voit, E., 'Zeitschrift f. Biol.,' vol. 41, p. 550, 1901.

Address of the President, Lord Rayleigh, O.M., D.C.L., at the Anniversary Meeting on November 30, 1906.

Since the last Anniversary the Society has sustained the loss of twelve Fellows and two Foreign Members.

The deceased Fellows are :—

- Professor Lionel Smith Beale, died March 28, 1906.
 Sir Walter Lawry Buller, K.C.M.G., died July 19, 1906.
 Charles Baron Clarke, died August 25, 1906.
 Right Hon. Sir M. E. Grant Duff, G.C.S.I., died January 11, 1906.
 Professor Charles Jasper Joly, died January 4, 1906.
 Colonel Sir Alexander Moncrieff, K.C.B., died August 3, 1906.
 George James Snelus, died June 18, 1906.
 Professor Hermann Johann Philipp Sprengel, died January 14, 1906.
 General Sir Henry E. L. Thuillier, C.S.I.
 Rev. Canon H. B. Tristram, died March 8, 1906.
 Professor Harry Marshall Ward, died August 26, 1906.
 Professor Walter Frank Raphael Weldon, died April 13, 1906.

The Foreign Members are :—

- Professor Ludwig Boltzmann.
 Professor Samuel Pierpont Langley.

On this list are to be found the names of veterans distinguished in many branches of science and in public affairs. One name is a household word in

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every physical and chemical laboratory. It would be difficult, indeed, to enumerate the investigations which have owed their success to the invention of the Sprengel mercury pump. In other cases, scientific careers still in full activity have, unhappily, been cut short. I allude especially to Joly, Marshall Ward, and Weldon. Even within my term of office our discussions have been enlivened by Weldon's scientific enthusiasm and vigorous polemics.

On the Foreign list are two distinguished names. Professor Ludwig Boltzmann, of Vienna, was perhaps the first Continental physicist to take up the ideas of Maxwell's electric theory of light, of which he had early grasped the scope, and became for many years one of its most emphatic supporters. One of his earliest series of experiments was a determination of the influence of the crystalline quality on the dielectric constant of sulphur, with a view to comparison with its optical double refraction. In the theory of gases he is to be classed along with Clausius and Maxwell as one of the creators of the dynamical theory, on which he became the highest authority. By developing an idea originated by Bartoli he placed Stefan's law of intensity of natural radiation on a theoretical basis, and thus became the pioneer in the modern thermodynamics of radiant energy. He contributed to the advance of physical science by many other investigations, and by his books on Gas Theory, on Electrodynamics, and on Mechanics. I may perhaps be allowed to add that at the time of his unhappy death, Boltzmann's name was before the Council as proposed for one of our medals.

Professor Langley's work was more on the experimental side of physics. In his bolometer he applied electric resistance thermometry to radiation, and was thereby enabled to penetrate further into the important and mysterious region of the ultra-red than had before that time been possible. For this work he received the Rumford Medal in 1886. During the later years of his life his attention was largely occupied with the mechanical problem of flight, and his models attained a considerable measure of success. As Secretary to the Smithsonian Institution at Washington he did much to forward, by his co-operation and advice, all kinds of scientific investigation.

In the Report of the Council there has been laid before you an account of the work of the Council and of various Committees in a very wide field. The investigation of the terrible disease known as Sleeping Sickness has unhappily been marked by the tragic death of Lieutenant Tulloch, who has fallen a victim to his zeal in studying the disease in Uganda. Vigorous efforts are being undertaken to discover some therapeutic remedy for the malady. In the case of Malta Fever, too, the investigation of which was entrusted to the Royal Society by the Colonial Office, good progress has been

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made. It has been ascertained by the Society's Commission in Malta that the main source of propagation is the milk of infected goats. When this discovery was made the authorities of the island were at once warned of the danger in the milk supply, and the necessary precautions were taken. Since then the number of cases of fever in the hospitals has so greatly diminished as to afford good hope that this disease, which has been so great a scourge in Malta, may ere long be reduced to insignificant proportions or altogether exterminated.

I observe that a movement has been started in this country in aid of the Greek Anti-Malaria League. Professor Ronald Ross, than whom there is no higher authority, bears witness to the unexpected prevalence of the infection in most of the localities examined, and he is confident that practical results of the highest value would follow expenditure in combating the disease on lines already laid down. Although I speak only from general knowledge, I cannot let this opportunity pass without emphasising my sense of the enormous importance of this class of work. If men knew where their real interests lie, our efforts in this direction would be doubled or quadrupled. In this way discoveries, which the future will certainly bring, might be accelerated by decades, giving health and life to thousands or millions who now succumb. Willing and competent workers would soon offer themselves; the principal obstacle is the want of means.

The preparation of the 'Royal Society Catalogue of Scientific Papers' for the remaining portion of the 19th century, which has proved a task so much more gigantic than can have been contemplated by the originators of the Catalogue nearly half a century ago, has been actively pushed forward. In consequence of the increased expenditure, now at the rate of nearly £2000 a year, the funds available are again approaching exhaustion. The difficulties of the President and Council and of the Catalogue Committee on this subject have once more been promptly resolved by the action of our Fellow, Dr. Ludwig Mond, who, after consultation with the Officers, has again made himself responsible for a further subsidy amounting to £2000 a year for three years. It is hoped that with the balance in hand and other sources of income, including the Handley Fund of the Royal Society, the income of which is devoted to this purpose, this subvention will suffice for the preparation of the work and for passing it through the press. Since the Royal Society took this great national task in hand there has already been spent on it over £23,500, while on each occasion of financial stress Dr. Mond has come forward with the means of relief, his direct contributions, including that just promised, now amounting in the aggregate to £14,000. This great work when published will thus be a tangible memorial of Dr. Mond's practical insistence on

the importance of adequate indexes of the vastly increasing literature of science.

Of the activities working under the Royal Society the one with which I have been especially connected is the National Physical Laboratory.

In their Report for the past year the Executive Committee call attention to the loss they have sustained by the deaths of Sir Edward Carbutt and Sir Bernhard Samuelson, both members of the Committee and warm supporters of its work.

The Report shows continued progress. As a result of a memorial to the Chancellor of the Exchequer, signed by about 150 Members of Parliament, the Grant for building and equipment for the year was increased from £5000 to £10,000, and this has enabled the Committee to take in hand some urgently needed extension.

Buildings are now in course of erection for Metrology and for Metallurgical Chemistry, while the Engineering Laboratory is being doubled in area. The two last additions were called for in great measure in consequence of an arrangement with the India Office whereby the testing work required for the Indian Government, hitherto carried on at Coopers Hill, is to be transferred to the Laboratory. The Indian Government provide the testing machine and other appliances required for the work, and, in addition, have intimated their intention of placing in the charge of the Committee the very admirable electrical equipment now at Coopers Hill.

Towards the equipment of the Metallurgical Laboratory the Goldsmiths' Company have made a very generous donation of £1000, while the Governments of New Zealand and Western Australia have contributed £100 each to the equipment of the Metrological Laboratory.

The buildings of the Electrical Laboratory have been completed, and were formally opened by the Right Hon. R. B. Haldane in June last. On this occasion many representatives of electrical industry from various parts of the world, who were attending the special conferences of the Institution of Electrical Engineers, were present, and joined in the inspection of the Laboratory.

After the meeting Sir John Brunner announced his intention of subscribing £5000 towards the equipment of the various buildings now in hand.

A number of important researches, a list of which is given in the Report, have been published during the year, and others are in a forward state of preparation for publication. Dr. Carpenter and Mr. Edwards have completed the first part of their research into the properties of the copper-aluminium alloys for the Alloys Research Committee. Dr. Stanton and Mr. Bairstow have read a paper before the Institution of Civil Engineers on

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the effect of alternating stresses on steels. The work on electrical standards with the Ampère Balance, which has a special interest for myself, is well advanced. In the hands of Mr. Smith the measurement of the electrolytic deposits of silver, which represent the whole passage of electricity through the apparatus, has attained a remarkable precision and, what is perhaps more important, some anomalies met with at first seem to be on the road to elucidation. Mr. Campbell has made progress with his research on hysteresis in steel sheets, and Dr. Harker is engaged with interesting investigations in high-temperature thermometry.

Changes in the staff have taken place. Dr. Caspari resigned his position in order to take up private practice, while Dr. Carpenter has been appointed the first Professor of Metallurgy in the Victoria University of Manchester. The arrangements with the Indian Government have necessitated an alteration in the metallurgical division, and the Committee have thought it right to constitute a Department of Metallurgy and Metallurgical Chemistry, with a Superintendent in charge of the work. They have been fortunate in securing the services of Mr. W. Rosenhain as the first occupant of the post.

A question of importance has arisen as to the performance at the Laboratory of tests, partaking of a routine character, on the physical and mechanical properties of specimens of material. To this objection has been taken on the ground of competition with the work of private establishments. In one of its aspects the question is financial. But the Executive Committee are of opinion that, even if the pecuniary loss were recouped, the efficiency of the Laboratory would suffer from the abandonment of this work. While anything like unfair competition with private establishments should be avoided, the execution of tests is good practice for the staff, and tends to keep them in touch with the manufacturers and with the practical problems which may demand examination. In view of the difference of opinion that has manifested itself, the Treasury has decided to appoint a small committee to inquire into the working of the Laboratory, with a special reference to this question.

On a former occasion, my distinguished predecessor, Sir William Huggins, called attention to some of the more important matters on which the Society in the past had initiated, supported, or given advice about scientific questions in connection with the State, and in other ways had made its influence felt strongly for the good of the country. It would hardly become me, with my short experience of the working of the Society, at least in recent years, to pursue this theme. The function of the Society which lies most open to the observation of an incoming President is that exercised at the ordinary meetings. I am impressed with the difficulty, arising out of the ever-

increasing specialisation of science, in rendering really useful the reading of papers and discussions thereupon. It is, of course, felt more severely in a Society like our own, which embraces within its scope the whole scientific field. It not infrequently happens that a paper is addressed to an audience among whom there is no one competent to follow the detailed observations and reasonings of the author. I am sometimes reminded of a saying of Dalton's on similar occasions at Manchester, quoted by Sir Henry Roscoe in his genial and entertaining 'Reminiscences': "Well, this is a very interesting paper for those that take any interest in it." A little more discretion on the part of readers of papers in having regard to the composition of their actual audience would be helpful here. In some cases experimental illustration would bring home to a larger number what is followed with difficulty from a merely verbal statement. But I am afraid that no complete remedy is within reach.

Increase of specialisation, however inconvenient in some of its aspects, is, I suppose, a necessary condition of progress. Sometimes a big discovery, or the opening up of a new point of view, may supersede detail and bring unity where before there was diversity, but this does not suffice to compensate the general tendency. Even in mathematics, where an outsider would probably expect a considerable degree of homogeneity, the movement towards diversity is very manifest. Those who, like myself, are interested principally in certain departments, and can look back over some 40 years, view the present situation with feelings not unmixed. It is disagreeable to be left too far behind. Much of the activity now displayed has, indeed, taken a channel somewhat remote from the special interests of a physicist, being rather philosophical in its character than scientific in the ordinary sense. Much effort is directed towards strengthening the foundations upon which mathematical reasoning rests. No one can deny that this is a laudable endeavour; but it tends to lead us into fields which have little more relation to natural science than has general metaphysics. One may suspect that when all is done fundamental difficulties will still remain to trouble the souls of our successors. Closely connected is the demand for greater rigour of demonstration. Here I touch upon a rather delicate question, as to which pure mathematicians and physicists are likely to differ. However desirable it may be in itself, the pursuit of rigour appears sometimes to the physicist to lead us away from the high road of progress. He is apt to be impatient of criticism, whose object seems to be rather to pick holes than to illuminate. Is there really any standard of rigour independent of the innate faculties and habitudes of the particular mind? May not an argument be rigorous enough to convince legitimately one thoroughly

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imbued with certain images clearly formed, and yet appear hazardous or even irrelevant to another exercised in a different order of ideas? Merely as an example, there are theorems known as "existence-theorems" having physical interpretations, the object of which is to prove formally what to many minds can be no clearer afterwards than it was before. The pure mathematician will reply that even if this be so, the introduction of electrical or thermal ideas into an analytical question is illogical, and from his own point of view he is, of course, quite right. What is rather surprising is that the analytical argument should so often take forms which seem to have little relation to the intuition of the physicist. Possibly a better approach to a reconciliation may come in the future. In the meantime we must be content to allow the two methods to stand side by side, and it will be well if each party can admit that there is something of value to be learned from the point of view of the other.

In other branches, at any rate, the physicist has drawn immense advantage from the labours of the pure analyst. I may refer especially to the general theory of the complex variable and to the special methods which have been invented for applying it to particular problems. The rigorous solution by Sommerfeld of a famous problem in diffraction, approximately treated by Fresnel, is a case in point. We have moved a long way from the time when it was possible for the highest authority in theoretical optics to protest that he saw no validity in Fresnel's interpretation of the imaginary which presents itself in the expression for the amplitude of reflected light when the angle of incidence exceeds the critical value. In this connection it is interesting to remember that, in his correspondence with Young, Laplace expressed the opinion that the theoretical treatment of reflexion was beyond the powers of analysis. The obvious moral is that we are not to despair of the eventual solution of difficulties that may be too much for ourselves.

As more impartially situated than some, I may, perhaps, venture to say that in my opinion many who work entirely upon the experimental side of science underrate their obligations to the theorist and the mathematician. Without the critical and co-ordinating labours of the latter we should probably be floundering in a bog of imperfectly formulated and often contradictory opinions. Even as it is, some branches can hardly escape reproaches of the kind suggested. I shall not be supposed, I hope, to undervalue the labours of the experimenter. The courage and perseverance demanded by much work of this nature is beyond all praise. And success often depends upon what seems like a natural instinct for the truth—one of the rarest of gifts.

MEDALLISTS, 1906.

The Copley Medal is awarded to Professor Elias Metchnikoff, For. Mem. R.S., on the ground of his distinguished services to zoology and to pathology, particularly for his observations on the development of Invertebrates and on phagocytosis and immunity. From 1866 to 1882 Professor Metchnikoff's work was exclusively zoological, and mainly during that period he produced a series of brilliant memoirs dealing with the early development and metamorphoses of Invertebrates.

Although his name stands in the first rank of investigators of these subjects, the most celebrated of his discoveries are those relating to the important part played by wandering mesoderm cells and white blood-corpuscles in the atrophy of larval organs, and in the defence of the organism against infection by Bacteria and Protozoa. It was on these researches that he based his well-known 'Phagocyte Theory.' Metchnikoff's fundamental observations were made in Messina in 1882, and were published in the following year. In these he showed that the absorption and disappearance of the embryonic organs of Echinoderms were effected by wandering mesoderm cells, which devoured and digested the structures which had served their purpose and become effete. The observation that white blood-cells accumulate in an inflamed area after infection by Bacteria suggested that these cells might also devour and thus destroy the invading microbes, and that the process of inflammation was really a physiological and protective reaction of the organism against infection. The study of the infection of *Daphnia* by *Monospora bicuspidata* entirely justified this prediction. The account of the phenomena of infection as seen in this transparent Crustacean was published in 'Virchow's Archiv' (vol. 96) in 1884, while, later in the same year, Metchnikoff published another paper extending these observations to Vertebrates, and showing the universal applicability of his generalisation as to the essential character of the inflammatory process.

During the twenty years which have elapsed since the publication of the 'Phagocyte Theory,' Metchnikoff, with the assistance of a host of pupils and disciples from all parts of the world, has been continuously engaged in the study of the reaction of the organism against infection, and in investigating the essential features of immunity in the light of the illuminating generalisation laid down in 1884.

Though of limited range, and therefore inferior in scientific importance to the more fundamental researches carried out by him previously,

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Metchnikoff's recent work on infection by the micro-organism of syphilis and the attainment of protection and immunity against this disease may be mentioned on account of its important practical applications.

It is not too much to say that the work of Metchnikoff has furnished the most fertile conception in modern pathology, and has determined the whole direction of this science during the last two decades.

The Rumford Medal is awarded to Professor Hugh Longbourne Callendar, F.R.S., for his experimental work on heat.

Professor Callendar has devoted his attention chiefly to the improvement of accurate measurement in the science of heat by the application of electrical methods. His first paper "On the Practical Measurement of Temperature," 'Phil. Trans.,' 1887, paved the way for the application of the electrical resistance thermometer to scientific investigation. In a later paper, written in conjunction with Griffiths, "On the Boiling Point of Sulphur, etc.," 'Phil. Trans.,' 1891, the application of his method was further extended, and a simple method of standardisation was proposed. In continuation of this work Professor Callendar has written a number of subsidiary papers dealing with details of construction of instruments, and applications to special purposes. The results of this thermometric work have since been confirmed by Chappuis and Harker, 'Phil. Trans.,' 1889, at the Bureau International, Paris, and by other observers, and are now generally accepted.

More recent developments in accurate electrical thermometry have been described by Professor Callendar in later papers. He has also devised a special type of "gas-resistance" thermometer, depending on the increase of viscosity of a gas with temperature, which is the exact analogue of the electrical resistance thermometer, and possesses peculiar advantages for high-temperature measurements.

The application of electrical resistance thermometers and thermo-couples to the observation of rapid variations of temperature has been utilised by Professor Callendar in the study of the adiabatic expansion of gases and vapours, and in the observations of the cyclical changes of temperature of the steam and of the cylinder walls in a steam-engine. The latter research was undertaken in conjunction with Professor Nicholson, with a view to elucidate the theory of cylinder-condensation.

The researches of Rowland and other experimentalists on the specific heat of water, and the mechanical equivalent of heat, had shown that grave uncertainties affected the value of this most fundamental physical constant, which could not be removed satisfactorily without a complete investigation of the variation of the specific heat of water between 0° and 100° C. Professor

Callendar devised a continuous electrical method of attacking this problem, possessing many important advantages as compared with older methods. He was assisted by Dr. Barnes in carrying out this work, the results of which form the subject of papers by Callendar and Barnes in the 'Phil. Trans. Roy. Soc.,' 1901. As an illustration of the probable accuracy of their results it may be observed that, whereas by any of the older formulæ accepted for the variation of the specific heat of water the values of Rowland and of Reynolds and Moorby for the mechanical equivalent are seriously discordant, they are brought into perfect agreement by the work of Callendar and Barnes.

In the subject of conduction of heat Professor Callendar has contributed many original methods described in various minor papers, and, in addition to the thermal investigations with which his name is chiefly associated, has carried out some purely electrical researches.

One of the Royal Medals has been awarded, with the approval of His Majesty, to Professor Alfred George Greenhill, a Fellow of the Society, on account of the number and importance of his mathematical investigations produced between the year 1876 and the present time. They embrace a variety of mechanical and physical subjects, including dynamics, hydromechanics, electricity, and gunnery. He is the author of two treatises on hydromechanics, both remarkable for originality of treatment.

The subject, however, to which he has devoted most time and attention is the theory of elliptic functions. His work on this subject may be placed in two classes: (1) Investigations in which he has extended the subject into new fields, as in the series of memoirs on the "Transformation and Complex Multiplication of Elliptic Functions," contributed to the 'Proceedings of the London Mathematical Society' (vols. 19, 21, 25, 27), and in the memoir on the "Third Elliptic Integral and the Ellipsotomic Problem," in the 'Phil. Trans.' (vol. 203). (2) Applications to Mechanical Problems, mainly dynamical, for purposes of calculation or illustration. In this class may be placed his treatise on the Elliptic Functions, as well as numerous papers in journals and the proceedings of scientific societies.

All Professor Greenhill's work is characterised by much originality, and by a rare power and skill in algebraic analysis.

His Majesty has also approved the award of a Royal Medal to Dr. Dukinfield Henry Scott, also a Fellow of the Society, for his investigations and discoveries in connection with the structure and relationship of fossil plants. Dr. Scott began the very important work which he has accomplished in this subject by helping the late distinguished palæo-

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botanist, Professor W. C. Williamson. In this co-operation he greatly enhanced the value of Williamson's work. He not only added many new discoveries, but, what was more important, demonstrated the value of the work in relation to phylogeny.

Dr. Scott has since added much of first-rate importance. He has discovered and elucidated many important types, his work constituting a most valuable acquisition to botany from the evolutionary point of view. It is not only in the accurate investigation of difficult structures that Dr. Scott has been so successful; not the least of his merits lies in the philosophical treatment of the problems suggested by his discoveries. His position as one of the leading palæobotanists in the world is well recognised. He has, both by his personality and by his writings, exercised a well-marked and widespread influence on the work of other botanists. The fact that he has created in this country a vigorous school of palæobotanists may be regarded as an additional claim for the honour now conferred upon him.

The Davy Medal is given to Professor Rudolf Fittig, Professor of Chemistry in the University of Strassbourg, who began to publish scientific work as early as 1858 and in 1864 discovered the method for the synthesis of hydrocarbons homologous with benzene, which has ever since borne his name. Up to about 1880 he worked chiefly on benzene derivatives, but his attention was gradually attracted to the study of lactones and acids, both saturated and unsaturated, which has largely formed the subject of his numerous published papers down to the present day.

Fittig has been a remarkably active worker. The Royal Society Catalogue contains under his name alone 96 papers, and, jointly with students and others, 71 more down to 1883. Since that time a number about equally large has been recorded in the indexes of the chemical journals. The work of Fittig and his students on lactones and acids, and particularly the intermolecular changes which many unsaturated acids undergo, may be said to be classical, and it has had an important influence on the progress of theoretical chemistry.

The Darwin Medal has been awarded to Professor Hugo de Vries, For. Mem. R.S. Professor de Vries has made a series of important discoveries in connection with the manner in which new races of organisms may originate, and he has materially extended and systematised our knowledge of the laws affecting the results of hybridisation. His work is the outcome of very extensive experiments that have been carried on for many years. He has stimulated numerous investigators, both in Europe and in America,

to extend these enquiries; and the results already obtained are of great importance, both from a theoretical and from a practical point of view. De Vries' work has exercised considerable influence on other branches of biology, and has suggested new lines of investigation in many directions.

Mrs. W. E. Ayrton is the recipient of the Hughes Medal, which is awarded for original discovery in Physical Sciences, particularly electricity and magnetism, or their applications. Her work on the Electric Arc has been described in a paper published in the 'Philosophical Transactions,' and in various other publications.

Mrs. Ayrton's investigations cover a wide area. She discovered the laws connecting the potential difference between the carbons of an arc with the current and with the distance between them, and proved these to apply not only to her own experimental results but to all the published results of previous observers. Dealing with the modifications introduced into the arc by the use of cores in the carbons, she found the causes of these modifications. The peculiar distribution of potential through the arc was traced, and its laws were discovered by her.

Having found the conditions necessary for maintaining a steady arc, and for using the power supplied to it most efficiently, she was able to explain the cause of "hissing," and the causes of certain anomalies in the lighting power of the arc.

For the past four years Mrs. Ayrton has been engaged in investigating the causes of the formation of sand ripples on the seashore.
